FIX-FAX #33

CALIFORNIA DEPARTMENT OF FORESTRY
AND FIRE PROTECTION

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Cooling System Maintenance (Diesel)

It is common belief that as long as the cooling system does not overheat, all is well. However, many problems can develop due to poor cooling system maintenance that are not always accompanied by coolant overheating. Below is a list of some of these problems:

- Low coolant temperature
- Solder Corrosion
- Cavitation corrosion of liners and water pump impellers
- Plugging of radiators and oil cooler cores
- Degradation of water pump seals and crevice seals
- Plugging of hoses and other coolant passages
- "Hot spots" that can cause piston scoring, cracked injector sleeves, and cracked heads.

Proper maintenance of the cooling system will control and/or prevent all of the above problems. The following is a discussion of coolant functions, reasons for use of a corrosion inhibitor, filtration, and problems that occur due to a lack of maintenance.

Recommend installation of a coolant filter on all Caterpillar engines. The coolant for a diesel engine must have three (3) components: water, antifreeze, and corrosion inhibitor. The main functions of the water/antifreeze mixture are to provide a good media for heat transfer and to provide freeze protection. The corrosion inhibitor's job is to prevent deterioration of the various parts of the cooling system (radiators, liners, oil coolers, water pumps, etc.) Most antifreeze formulas have some corrosion inhibitors added, but these additives are not sufficient to provide the protection required by diesel engines. Therefore, a corrosion inhibitor should perform all of the following functions:

CORROSION PROTECTION: The inhibitors in a coolant must prevent corrosion to steel, cast iron, aluminum, copper, brass, and solder. Galvanic corrosion of the cooling system can occur because all of these metals are in contact with the same solution (coolant). In galvanic corrosion, a chemical reaction occurs that essentially removes metal from one component and oxidizes (adds oxygen) to the metal in another component.

The best example of galvanic corrosion in cooling systems is the corrosion of solder (called "solder bloom"). In this reaction, the lead in the solder oxidizes. The increase in mass causes the solder to "bubble up" and choke off radiator and oil cooler tubes. The resulting reduction in coolant flow can be very damaging to the engine. Galvanic corrosion can also cause failure of radiator top and bottom tanks, injector sleeves, cooling system pipes and elbows, oil coolers, and radiator header plates.

CONTROL OF SCALE AND OTHER DEPOSITS: Some chemicals in a coolant have a tendency to precipitate (drop out of solution as a solid) and deposit on the metal surfaces in the cooling system. If a scale of these deposits form on a liner or other critical heat transfer surface, the heat transfer process can cause "hot spots" resulting in head and block cracking, accelerated piston ring wear, scuffed cylinders and pistons, and burned valves. Hard water can often be the cause of scale build up on cooling system components. Corrosion inhibitors are designed to keep more of these scale formers in solution.

CAVITATION PROTECTION: Cavitation is a type of erosion-corrosion (usually called pitting) caused by the collapse of vapor bubbles at the surface of a vibrating liner or spinning water pump impeller. The bubbles form and collapse due to pressure variations at or near a rapidly moving surface. A cylinder liner vibrates because of piston slap as the piston moves up and down within the cylinder. The outside wall of the liner first moves away from the coolant, causing an area of low pressure near the liner surface. The low pressure then causes the coolant to vaporize and a bubble is formed. When the liner moves toward the coolant, the pressure increases greatly, causing the bubble to collapse. The pressure wave from the collapsing bubble weakens and blasts away the metal at the surface of the liner. The damage is both mechanical and corrosive in nature.

Corrosion inhibitors have ingredients that form a thin but tough layer of oxide on cast iron and steel surfaces. The collapsing bubbles only damage the oxide layer, which is quickly reformed. If the corrosion inhibitors are depleted considerably, or if there are air bubbles in the cooling system, a liner or water pump impeller can fail in 50,000 miles or less.

BUFFERING: The pH of the coolant should be held in the slightly alkaline range of 8.5 to 10.5 to neutralize active blow-by gases that enter the cooling system. An alkaline pH of 11.0 or greater will result in corrosion to aluminum and solder, and an acid pH of 7.0 or less will accelerate corrosion of cast iron, steel, and aluminum. A low pH can also cause additive precipitation and breakdown. Chemicals are in corrosion inhibitors to maintain the pH of the coolant at the required level.

PREVENT FOAMING: Foaming of the coolant can be caused by a number of cooling system problems, all of which result in entrainment of air or blow-by gases in the coolant. Whatever its cause, foaming can cause severe pitting of the liners and water pump impellers, increased corrosion rates, and greatly reduce cooling system efficiency. Anti-foam agents are included in most corrosion inhibitors and antifreezes.

To perform their intended functions, the chemicals added to the coolant must remain in solution and not undergo unwanted side reactions. It is normal for corrosion inhibitors to deplete at a slow rate as they maintain a protective film on the metal surfaces within the cooling system. Field experience on the DCA inhibitor shows an average depletion rate of 0.3 to 0.4 oz./gal. in 10,000 to 15,000 miles. With this rate of depletion, the corrosion inhibitor must be periodically tested and the cooling system returned to the proper chemical concentration.

Inhibitor depletion can be accelerated by high coolant temperatures, high engine loading, excessive amounts of blow-by gas, leakage, or entrainment of air in the coolant, make up water with excessive mineral content, lubricating oil in the coolant, coolant leakage, a dirty system containing a large amount of corrosion products, precipitated inhibitors, and a low inhibitor concentration.

It is obvious from the above discussion that cooling system maintenance is a necessity for diesel engines. Recent engine failures in the Department’s diesel-powered equipment further supports a more diligent maintenance program for cooling systems. These solids, if present in the coolant, will increase corrosion rates, block thermostats open, cause plugging of radiator and oil cooler tubes, leave oily residues on critical heat transfer surfaces, and leave deposits on water pump face seals. Abrasive particles of core sand, silt or mineral scale will cause wear to water pump impellers and shafts, water pump face seals, crevice seals, and thermostats.

Inspection of a used coolant filter can reveal possible engine problems. If the filter contains oil and fuel, it would indicate that an oil cooler or injector sleeve is at fault. The filter element that contains large amounts of precipitated inhibitors would indicate over-extended use of antifreeze, over-concentration of inhibitors, or make-up water that is excessively hard. Finding bits of crevice seal material can indicate a liner seal problem. The above are some of the ways that filter can point out and isolate engine problems, which in turn can prevent further engine damage.

There are a number of combination filter/inhibitors available through the engine manufacturer. Contact your local dealer for assistance in selecting proper filters which offer maximum protection.

In summary, the cooling system is an integral part of the engine. Neglect of the cooling system means slow degradation of the engine.

(Excerpts from Cummins Engine Corporation)

(see FIX-N-FAX INDEX)